ANALYSIS OF ARABIAN SEA OXYGEN TIME SERIES

Chris Langdon
Lamont-Doherty Earth Observatory of Columbia University
Palisades, NY 10964
914/365-8641, langdon@ldeo.columbia.edu

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LONG-TERM GOALS

My long term goal is to understand the processes responsible for seasonal changes in phytoplankton abundance and bio-optical properties of the surface ocean. Net production is the most fundamental process which controls the abundance of phytoplankton. The phytoplankton in turn are important as the dominant absorbing, scattering and light emitting particles in the open ocean and as a food resource for acoustic scattering zooplankton. I want to understand how physical processes control the light and nutrient fields in which the phytoplankton grow. I also want to learn how various phytoplankton species adapt to light or nutrient limited environments. Ultimately I would hope to be able to predict which species would be expected in a particular environment and the probable range of their abundance.

OBJECTIVES

- Compare the observed diel oxygen signal with modeled temporal oxygen variability at the central Arabian Sea mooring site (15.5°N 61.5°E) in terms of light, quantum yield, absorption cross section, respiration, entrainment, mixed layer depth and parameterizations of air-sea exchange and air injection.
- Relate changes in net community production derived from the oxygen time series with meteorological and hydrographic time series.
- Relate diurnal and seasonal changes in the net community compensation intensity with changes in zooplankton abundance predicted by the ADCP mounted on the Rudnick SIO mooring.

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APPROACH

My approach to this complex problem is to collect a high temporal resolution time series of diel oxygen variability and as many concurrent physical parameters as is technically feasible. This phase of the work has been completed. My next step is to build a mathematical model of mixed layer oxygen dynamics. My approach is to start with the simplest possible representation of photosynthesis and gas exchange. The model will be forced with the actual light intensity time series collected at the mooring. At each step the modeled variability will be compared with the observed. The effect of adding seasonally variable PI parameters obtained from the JGOFS process cruise PIs will be

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evaluated. Parameterizations of entrainment and air injection will be evaluated to see if they add realism to the modeled oxygen time series. Finally knowledge gained from the numerical modeling exercise will be used to create a time series of net primary productivity based on gas exchange corrections applied to the diel oxygen variability time series. Seasonal and shorter time scale changes in net community productivity will be related to changes in the physical environment. Particular attention will be paid to the seasonal changes in depth of the mixed layer depth and oxygen minimum layer associated with the north-eastern monsoon.

WORK COMPLETED

1. Mooring oxygen sensor data has been calibrated against hydrocast oxygens collected along side the mooring during the deployment. Plots of the time series are available in the LDEO mooring data reports. Digital data is available at the LDEO web page (http://www.ldeo.columbia.edu). Click on data repositories, then Bioinfo, and then mooring data Arabian Sea.
2. A multi-authored paper was written in which a figure of diel oxygen variability time series is given and a discussion is given of the possible cause and effect relationship between shoaling isotherms, high levels of shear and high level of diel oxygen variability (Rudnick, Weller et al. 1997).
3. A photosynthesis-gas exchange numerical model has been developed in MathCad. Output from this model for various combinations of oxygen saturation, mixed layer depth and gas transfer velocity was used to get a feeling for how the magnitude of the gas exchange correction varies over the mooring time series. The results of this analysis was presented at the JGOFS Arabian Sea Data Workshop in Durham, NH and will be the topic of my presentation at the AGU Ocean Sciences meeting in San Diego.

RESULTS

A simple model of photosynthesis based on absorption cross section and maximum quantum yield was initialized with parameter values measured during the JGOFS process cruises and forced with the light and chlorophyll levels observed at the mooring. This produced a time series of diel oxygen variability based on photosynthesis alone. In a second model run I added the process of gas exchange using the wind speed parameterization of Liss and Merlivat (1986). The ratio of diel oxygen variability (dawn-to-dusk increase) to the oxygen increase if gas exchange flux was zero (i.e. the actual photosynthetic production) varied from 0.63 during Oct. 94 to 1.01 in Jan. 95. The most interesting result was that over the majority of the period from Oct. 15, 1994 to Mar. 5, 1995 the ratio fell within the range 0.9-1.0, that is to within ±10% the observed diel oxygen variability is providing a quantitative estimate of the net primary productivity of an unconfined natural population of plankton. On Jan. 25, 1995 net oxygen productivity was measured by Mary-Lynn Dickson at a station located close to the mooring. The dawn-to-dusk increase of oxygen in a bottle incubated at a depth of 10 m was 9.2 μM while the gas exchange corrected diel oxygen variability record by the 2 and 10 m oxygen sensors on the mooring was 3.8 μM (3.9 μM uncorrected). I would argue that the difference in these two measurements is due in large part to the fact that the phytoplankton in Mary-Lynn's bottle were held at a constant depth and therefore received more light than the unconfined phytoplankton which were being mixed over a depth of 90 m during the incubation. If I assume that the photosynthesis in the bottle is proportional to the amount of light received and I multiply the production in the bottle by the ratio of average mixed layer irradiance to irradiance at 10 m I get an estimate mixed layer production of 2.9±0.5 μM compared with the estimate based on *in situ* diel oxygen variability of 3.8 μM. It is interesting that *the in situ* rate is about 30% greater than the bottle rate. This may be an indication that turbulence and vertical motion play a significant role in the lives of phytoplankton. This would be a very interesting result. It would be reasonable to expect that nutrient uptake would be enhanced in a turbulent environment. Obviously many more comparisons of in situ and bottle rates must be performed to verify this result.

IMPACT

The methods I am developing will eventually permit the measurement of net productivity of unconfined natural populations of plankton. This will allow us to quantify the effects of turbulence and vertical motion on plankton rate processes in a direct way that has not been possible with bottle incubation methods.

TRANSITIONS

RELATED PROJECTS

REFERENCES

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